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SOVIET OIL AND GAS RESERVES

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Following our telephone conversation on 13 February 1974 I spoke with one of my colleagues on the availability of information on Soviet oil and gas reserves. He informed me that he had made some collection effort and had drawn up some rough notes on the results of these efforts.

25X1

[Redacted]

If you have any questions you can direct them to

[Redacted]

who can be reached on

[Redacted]

STAT

Sincerely,

25X1A

[Redacted]

Enclosure:
(as stated)

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Soviet Oil and Gas Reserves

General Background

There is no way to equate precisely Soviet reserve classifications for (A), (A + B) or (A + B + C₁) categories to the US concept of proved reserves. Soviet definitions, unlike the US concept, do not specify that the reserve must be commercially exploitable with available technology and equipment. Also, the density of the exploratory well network on any structure is relatively more sparse in the USSR than in the US. Soviet A reserves can usually be treated as available reserves established through drilling, while B and C₁ categories are less probable and they are inferred by the extrapolation or interpolation of known subsurface data to progressively larger surrounding areas. Prior research on Soviet reserves has produced the following observations to date:

1. The publication of natural gas reserve data in the USSR appears to be unrestricted and encouraged, while the disclosure of crude oil reserve data is prohibited by the State Secrets Act of 1947.

2. A search of Soviet literature will provide two basic types of data which can be used to estimate crude oil reserves: the publication of periodic link relatives that can be used to chain bits of information from the past to the present, and reporting of ratios of reserves to production (R/P). For example, Vyshka (Baku, 16 June 1971, p. 2) stated that explored reserves of oil increased 1.7 times in the past 10 years (1961-1970). Data gleaned from Soviet literature were presented by the National Petroleum Council (NPC) in a 1962 report which indicated explored (A + B) oil reserves

constituted a 20-year supply, or some 3 billion tons as of January 1, 1961. More recently Neftyanaya Khozyaistvo (No. 6, 1968, p. 1-8) reported that the R/P on January 1, 1968 had declined 35% since 1955 (i.e., from more than a 28-year supply down to a little more than an 18-year supply) and 18% since 1961 (i.e., down to a little more than a 15-year supply).

3. Another published indicator, the average discovery rate of oil or gas per meter of exploratory drilling, is less useful in estimating reserves because the drilling base used in the Soviet computation almost never agrees with the published figures for exploratory drilling. Apparently no distinction is made between oil and gas deep well meterage, and shallow stratigraphic reconnaissance tests, limited to 300 meter depths. The 1970 Soviet Statistical Yearbook (p. 186) reported a total of 26.6 million meters of exploratory drilling for the 1966-1970 period. A trade journal Neftyanik (No. 3, 1971, p. 3) indicated that only 15.2 million meters of deep exploratory wells were drilled during this period. Another journal article infers that some 6.6 million meters of exploratory drilling for oil were recorded during 1966-1970 and that the discovery rate increased to 220 tons per meter from 169 tons per meter during 1961-1965 Neftgazovaya Geologiya i Geofizika (No. 1, January 1971, p. 3-7). The lower discovery rate may have applied to additions of only A + B reserves during 1961-1965, and the higher rate to A + B + C₁ reserves during 1966-1970. Whereas, cumulative oil production amounted to 1.54 billion tons during the last 5 year plan, the announced discovery rate (220 tons X 6.6 million meters) would indicate that only 1.45 billion tons was found. This draw-down of oil reserves agrees with

other Soviet geologists' remarks and it corresponds to similar statements made for the 1961-1965 period. The NPC Report (1962 Vol. II, p. 104-108) estimated that crude oil was discovered at an average rate of 55 tons per meter of total drilling during 1947-1960, and unproduced reserves of A + B oil amounted to 3.0 billion tons, on January 1, 1961. The same methodology can be used to check the published link relatives for additions to oil reserves during 1961-1970. If crude oil reserves in A + B categories grew by 1.5 times between 1961-1965 and by 1.3 times between 1966-1970 as claimed by the USSR, unproduced reserves would have reached 6.0 billion tons on January 1, 1971. An estimate of 6.0 billion tons appears high and it would contradict statements that withdrawals exceeded additions over the decade but the difference may reflect the inclusion of C₁ oil reserves after 1965. Also gross discoveries (total crude oil produced plus net additions to reserves) would have amounted to 5.55 billion tons as a result of 104,133,000 meters of total drilling which yields a similar discovery rate of about 53 tons per meter throughout 1961-1970.

4. Unproduced oil reserves of 6.0 billion tons on January 1, 1971 should represent the upper limit of a feasible range of Soviet oil reserves. The lower limit can be derived from a link relative appearing in Vyshka (April 7, 1963, p. 1) which stated that oil reserves in the USSR increased 3.3 times in the last 20 years (1943-1967). According to Professor Campbell, Economics of Soviet Oil and Gas, (p. 70), 1948 reserves were between 0.6 and 1.0 billion tons and they could have increased to only about 2.0-3.3 billion tons on January 1, 1968, when

inflated by the coefficient of 3.3. This estimate appears to be too low, because Campbell (p. 81) previously estimated unproduced oil reserves at 3.52 billion tons in (A + B) categories on January 1, 1966, and the Soviets indicate these reserves increased by 1.3 times during 1966-1970, or to 4.58 billion tons on January 1, 1971, which would provide a more reasonable lower limit to a feasible range of 4.5 to 6.0 billion tons of unproduced oil on January 1, 1971.

5. As indicated previously, Soviet reserves after 1965 may have included A + B + C₁ categories instead of just A + B classifications. Since the literature is unclear on this point some correction for C₁ reserves is desirable. During the 1960's, C₁ reserves amounted to 43%-59% of the total figure for A + B + C₁ reserves reaching 59% on January 1, 1967, according to Ekonomika Neftedobyvayushchei Promyshlennosti, (No. 3, 1968, p. 16-19). The same journal (No. 4, 1968, p. 7) further stated that 40% of C₁ oil reserves were written-off between 1963-1967 as a result of further exploratory drilling. Furthermore, two very prominent Soviet geologists writing in Geologiya Nefti i Gaza (No. 11, 1967, p. 34-38) reported that 31% of the A + B oil reserves were also written off during 1961-1965 and that of the reserves claimed on January 1, 1966, no more than 75% in the A + B categories can be considered confirmed.

Correction of the estimated feasible range of 4.5-6.0 billion tons of unproduced oil and January 1, 1971 by such write-downs would yield the following results:

Oil Reserves

<u>Low Estimate</u>	<u>High Estimate</u>
	4.5 BTO (A + B on 1/1/66)
	<u>.9</u> BTO = (A + B additions in 1966-1970 from total additions of 1.5 BTO X .6)
4.5 BTO (A + B on 1/1/71)	5.4 BTO (A + B on 1/1/71)
X <u>.75</u> Correction factor for write-offs	X <u>.75</u> Correction factor for write-offs
<u>3.375</u> BTO proved on 1/1/71	<u>4.05</u> BTO proved on 1/1/71

6. Natural gas reserves appear to have increased most significantly during 1966-1970. M.S. L'vov disclosed in his book "Resursy Prirodnogo Gaza SSSR" (Moscow, 1969, p. 53) that Soviet natural gas reserves in A + B categories increased from 988 billion cubic meters on January 1, 1959 to 2.021 trillion on January 1, 1966. Likewise, A + B + C₁ reserve increased from 1.585 trillion to 3.566 trillion cubic in the same period. On January 1, 1967, the last official Soviet estimate for A + B gas reserves was reported at 2.189 trillion cubic meters and at the same time A + B + C₁ reserves were given as 4.431 trillion. L'vov also explained that the rationale behind the inclusion of C₁ reserves after 1965 (on p. 33) was to (i.e. ensure amortization) facilitate planning and investment decisions. By 1966, the reserves-production ratio in terms of A + B gas reserves in most of the major gas producing regions of the USSR fell within a 10 to 15-year supply at the most. Accepted amortization schedules required a larger reserve base and this led to the inclusion of the C₁ category. However, the C₁ reserve category has proven to be quite undependable and

a subject of considerable embarrassment. Inclusion of some C₁ reserves resulted in a doubling of A + B reserve estimates, only to find that actual production failed to reach the anticipated level. For example, in the Vukhtyl and Punga gas fields and in the Kalmyk ASSR and at Sakhalin C₁ reserves have been written down or discribed as unreliable.

7. Since 1967, the Soviet gas reserves have been stated exclusively in terms of A + B + C₁ categories, and as of January 1, 197⁴₂, they were claimed to exceed 1⁹₇ trillion cubic meters. Only 3.3 million meters of total drilling were reported for all of West Siberia during 1966-1970 according to Gazovaya Promyshlennost (No. 5, 1971, p. 6-7), during which time about 10 trillion cubic meters of gas were claimed to have been found in only 8 large gas deposits. However, Naftyanik (No. 1, 1971, p. 3-5) cited that exploratory drilling had been effectively discontinued after 1968 because of prohibitive costs. The total of 3.3 million meters, when adjusted for the drilling of some 1,200 development oil wells (about 2,000 meters deep) in the Middle Ob region, would infer that exploratory drilling could not have exceeded some 400,000 meters during 1966-1970. Assuming the discovery of 10 trillion cubic meters of gas in this region during the same period, the drilling of only 400,000 meters would infer a discovery rate of 25 million cubic meters per meter of exploratory drilling which defies credibility. In Gazovaya Promyshlennost (No. 5, 1971, p. 6) a discovery rate of 14.5 million cubic meters is claimed during 1966-1970, with 615,200 meters of exploratory drilling in West Siberia in contrast with a nationwide average of 1.3 million. Previously, however, the same

Journal (No. 1, 1971, p. 1-2) claimed a discovery rate of 202,000 cubic meters (A + B) for 1961-1965, and an increase to 1.058 million (A + B + C₁) during 1966-1970.

Despite limited exploratory drilling and possible exaggerated discovery rates, the role of C₁ reserves has assumed a much greater significance in "commercial" reserves (A + B + C₁) of gas since the mid 1960s, as shown in the following tabulation:

Reserves of Natural Gas

Billion Cubic Meters

<u>Year</u>	<u>A + B</u>	<u>A + B + C₁</u>
1958	988	1,585
1959	1,667	2,202
1960	1,885	2,336
1961	2,015	2,547
1962	1,942	2,786
1963	2,090	3,062
1964	2,091	3,220
1965	2,021	3,566
1966	2,188	4,431
1967	NA	5,100
1968	NA	7,753
1969	NA	9,200
1970	NA	13,000
1971	NA	15,000
1972	NA	16,000
1974	NA	19,000

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Campbell

THE ECONOMICS OF SOVIET OIL AND GAS

THE ECONOMICS OF SOVIET OIL AND GAS

Robert W. Campbell

John
Harcourt
1968

The 1940 plan for exploratory work set as a target the discovery of fifty-five new structures (compared with the annual rate of about 200 per year in the first five years after the war) and completion of exploration on twenty-four structures to the point where they would be ready for deep drilling (compared with 75-100 per year in the postwar period). In the prewar period the emphasis in the earlier stages was on geological work, and such geophysical work as was done was oriented more to general regional studies than to the preparation of structures for deep drilling. Most geophysical work in 1940 was by methods other than seismic. The eighteen seismic crews sent out in 1940 probably represent no more than nine crew years, and they were working with relatively unproductive equipment. At this time, the annual average number of seismic crews at work in the United States was 181 (API, *Petroleum Facts and Figures*, 1959 ed.). Exploratory drilling reached its prewar peak in 1936, and in 1940 only 359 exploratory wells were drilled, and very few of these could have been prospecting wells: over half of the footage of that year was drilled in Azerbaïdzhân, and only 55 of the 133 areas drilled were new prospects (Lisichkin, 1958, p. 34).

During the Second World War, exploration operations at first fell drastically, and then with the assistance of lend-lease supplies rose toward the end of the war. By 1946, the general level of exploration seems to have been somewhat above the 1940 level. From that point on, all the indicators of exploratory work show a rapid and continued rise. There was a strong shift toward seismic geophysical work, the number of structures prepared per year rose, and the number of structures on which deep drilling was being done rose far above the prewar level. The exploratory effort was shifted geographically to new areas, untouched before, and the share of prospecting wells increased. Altogether the Russians were now taking exploration seriously, and devoting much more effort to it.

OIL RESERVES

Although there is abundant information on gas reserves, information on oil reserves has been unavailable at least since its inclusion in the State Secrets Act of 1947.² The most recent absolute information on Soviet oil reserves goes back to the years immediately preceding the Second World War. The data, which are summarized in Table 5, suggest that A — B

² Despite the lack of definite information on Soviet oil reserves, there is no shortage of confident assertions about their magnitude. See, for example, Hassmann, *Oil in the Soviet Union*, Hodgkins, *Soviet Power, East, The Petroleum Industry of the Soviet Union*. The confusion is often compounded when one of these figures is described as "proved reserves," as in National Petroleum Council, *Impact of Oil Exports from the Soviet Union*, vol. II, p. 165. I have argued that no Soviet reserve concept is equivalent to the American concept of proved reserves.

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TABLE 5. SOVIET OIL RESERVES

(million tons)

Date (as of January 1)	Categories			
	A	A + B	A + B + C	A + B + C
1937	230.7	542.7	3,477.2	6,276.3
1938	n.a.	977.05	4,674.3	8,644.0
1940	n.a.	n.a.	n.a.	10,972.0

n.a. = not available.

Sources: PKh, 1939:8, p. 143; NKh, 1939:4-5, p. 16; *Vostochnaya neft'*, 1940:4, p. 4; Third Five Year Plan, p. 170.

reserves probably did not exceed about 1 billion tons in 1940, but it is unlikely that much trust can be put in these prewar reserve estimates.

For the postwar period, there are numerous statements concerning percentage increases in reserves. Most of these statements are ambiguous in that they do not specify clearly what reserve concept is involved. The usual reference is to *promyshlennyye* (commercial) or *razvedannyye* (explored) reserves, or both. These terms are not part of the official reserve classification, but it is fairly clear that they generally refer to the A + B concept. When all these statements are linked together, the index shown in Table 6 is the result. There are many suspicious things about this series, and many additional bits of information are not consistent with it.

Later in this chapter it is estimated that the A + B reserves of the Soviet Union on January 1, 1956, must have been about 2 billion tons, and this figure can be used to convert the index of Table 6 to a series in absolute terms. This leads to some riddles. It implies that A + B reserves in 1940 were only a little over 500 million tons, which is inconsistent with the claim that they were 997 million tons on January 1, 1938. On the other hand, if it is assumed that A + B reserves in 1940 really were about 1 billion tons, our index implies that they would have risen to 2.5 billion tons on January 1, 1951, 6.4 billion tons on January 1, 1956, and 9.6 billion tons on January 1, 1961. Such magnitudes, however, are not consistent with other information. They would mean gross additions to A + B reserves in the Fifth Five Year Plan (1951-55) of about 4.2 billion tons. In this period the Russians claim to have discovered only 253 new deposits of oil (new fields discovered plus new deposits discovered on previously known fields), and average reserves per newly discovered deposit of over 16 million tons is impossible.

The answer to the riddle may be that the link between 1940 and 1955 used in the construction of the index is wrong (it is given in only one source). Or it may be that prewar estimates of reserves were greatly exaggerated. Statements that there was about a 13-15 year supply of A + B

TABLE 6. INDEX OF GROWTH OF SOVIET OIL RESERVES (A + B), JANUARY 1

January 1	Index
1940 450 million tons	80
1946	100.0
1947	117.0
1948	137.5
1949	149.5
1950	164.0
1951	197.7
1952	333.0
1953	371.6
1954	423.3
1955	477.6
1956 2 billion tons	510.0
1957	556
1959	598
1961 3 billion tons	765
1965	897
1966 (plan)	1,017
1966 (actual)	

* Reserves on January 1, 1966, are reported as "more than 1.5 times January 1, 1959" in *GNIG*, 1965:6, p. 2, which suggests that there was no increase in 1965.

Sources: 1945 through 1957, Keller, 1955, pp. 5 and 6; a link between 1940 and 1955 is given in *Opyt razrabotki nefiannykh mestorozhdenii*, Moscow, 1957, pp. 30-1. Statements in *NKh*, 1959:9, p. 2, and 1961:10, p. 5, supply links to 1959 and 1961, and a statement in *GNIG*, 1965:4, p. 7, to 1965. The goal for the Seven Year Plan was to raise reserves by 1.7 times, and this figure is presumably the ratio between January 1, 1959, and January 1, 1966.

reserves in the years immediately preceding the Second World War when annual output was about 30 million tons, suggest that A + B reserves might have been 450 million tons rather than something on the order of 1 billion tons, as claimed at the time.

As Soviet exploration and production has moved eastward, the regional distribution of reserves has changed sharply, as shown in Table 7. The Volga-Ural area has become predominant in reserves as in production, though its share is likely to decline over the next decade. New reserves are being found in Central Asia, and Siberia. Also, in the older regions such as Baku and Krasnodar krai, exploration in deeper horizons and in offshore sites is once again revealing new reserves.

It is a pity to have so little information on the actual dynamics of Soviet reserves, in view of the importance of the question of the cost of finding new reserves. However, it is perfectly clear that Soviet "ultimate" reserves are large enough to support high levels of production for a long period of time. Soviet geologists estimate that some 29.4 million square kilometers of the earth's crust is overlain by sediments favorable for the accumulation of oil. Of this they calculate that the Soviet Union has 11.3 million square kilometers as against only 4.3 square kilometers for the United

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TABLE 7. DISTRIBUTION OF SOVIET OIL RESERVES BY REGION, CATEGORIES A + B, JANUARY 1
(per cent of total)

Region	1937	1946	1950	1955	1959
Volga-Ural	3.9	30.3	52.9	81.1	79.6
Azerbaijani	64.7	42.1	28.0	10.7	15.6*
Other	31.4	27.6	19.1	8.2	4.8
- Total	100	100	100	100	100

* Caucasus.

Sources: Fedorov, *Neftianye mestorozhdeniya Sovetskogo Soyuza*, 1939, 2nd edition, p. 530; and Keller, 1958, p. 6. The 1959 figure is from *VE*, 1959:12, p. 103.

States.⁴ Even if ultimate reserves are not precisely correlated with volume of sedimentary cover, the vast sedimentary areas of the Soviet Union imply ultimate reserves several times those of the United States. A recent survey has concluded that even given the extent to which U.S. oil reserves have already been depleted (cumulative oil production in the U.S. through 1963 is a little over 10 billion tons compared with 1.8 billion in the U.S.S.R.), it should still be possible to expand the present level of production to over 800 million tons in 1975 (Schurr, *et al.*, 1960, p. 386). Insofar as it depends on the availability of oil resources, the Soviet target of 690-710 million tons suggested for 1980 at the 22nd Party Congress in 1961 certainly should be feasible.

The sediments in which this oil is thought to exist have been only lightly touched by exploratory effort. One Soviet authority has estimated cumulative drilling per square kilometer of sedimentary cover in the Soviet Union at 8.7 meters as against 366 meters per square kilometer in the United States (NKA, 1962:1). If only exploratory drilling were considered, the difference between the two countries would be even greater because exploratory drilling represents a smaller share of the total drilling effort in the U.S.S.R. than it does in the U.S. Soviet exploratory effort has been concentrated in a relatively small part of the potentially favorable area, especially in the Caucasus region and the Volga-Ural area. Azerbaijan, in particular, has had a very high density of exploratory drilling. With only 6 per cent of the sedimentary cover, it has absorbed almost 20 per cent of total exploratory drilling for a density of 108.5 meters per square kilometer compared to an average of 4.1 for the U.S.S.R. as a whole. In Siberia and Central Asia, densities are far below the average.

⁴ This particular statement is found in NKA, 1962:1, p. 2, but it is also echoed in many other sources. Geologists outside the Soviet Union rate the Soviet situation as not quite so favorable relative to the United States. According to Eugene Stebinger, the U.S. area of sedimentary cover is about 6.4 million square kilometers compared to 11.0 for the U.S.S.R., Pratt, 1950, p. 232.

The significant variable in assessing future Soviet petroleum production and Soviet willingness to maintain large exports is how much it will cost to develop these reserves. The oil is undoubtedly there, but the costs of finding and producing it will change in response to the changing geological and technological situation.

PRODUCTIVITY IN EXPLORATION

It is difficult to draw firm conclusions about discovery costs of Soviet oil or changes in productivity of exploratory work over time because so little information is available. The restrictions on disclosing reserve figures make it virtually impossible for Soviet writers to discuss the issues. And the statistics are not organized to generate adequate information on effectiveness for either the exploratory effort as a whole or its intermediate stages. Such information as can be found is reviewed below. Though the evidence is far from satisfactory it does show rising cost trends, and it suggests that it is not easy for the Russians themselves to get a clear picture of exploration effectiveness.

Discovery and evaluation of new prospects. There is attrition at several points, from the beginning of the search for geological situations favorable for the accumulation of oil and gas, through the stage of drilling prospecting wells. (1) Only some of the newly discovered structures are selected for exploration by geological and geophysical techniques to prepare them for exploratory drilling. (2) Only a fraction of the structures studied in detail are subjected to exploratory drilling. For example, by 1958 exploratory drilling had been begun on only about 65 per cent of the structures prepared by geophysical methods in 1951-55, though a few more structures may eventually be drilled (GNIG, 1959:8, p. 4). For structures which had been mapped by core drilling, the attrition rate is even higher. (3) Exploratory drilling frequently reveals that the supposed structure does not actually exist. This was what happened in the case of 37 per cent of the structures prepared by core drilling in the 1951-55 period and 20 per cent of those prepared by seismic methods (Keller, 1959, pp. 9-10). Until recently, core drilling operations were almost universally limited to depths of about 300 meters because of the capabilities of the equipment available. Mapping had to be done on the shallower formations overlying the formations of interest, and in many cases the structures mapped did not extend to the older strata in which it was hoped to find oil.

Structures probed with prospecting wells do not always contain oil or gas. In the first six years of the Seven Year Plan, 1,903 structures were

TABLE 10. TRENDS IN SOVIET EXPLORATORY EFFECTIVENESS

Period	Meterage in exploratory wells (thousand meters)			All outlays on exploration in constant prices of July 1, 1955 (million rubles)			Number of new deposits discovered (oil only)	Gross discoveries of A + B oil reserves	
	Total	Gas	Oil	Total	Gas	Oil		(million tons)	Tons/ meter of exploratory drilling
Fourth Five Year Plan 1946-50	6,471	417	6,054	684	40	644	162	532	88
Fifth Five Year Plan 1951-55	11,615	1,250	10,365	1,608	86	1,522	223	1,497	141
Sixth Five Year Plan 1956-60	16,317	3,668	12,649	2,449	110	2,039	421	1,573	124
Seven Year Plan 1959-65	32,924	10,618	22,306	n.a.	n.a.	n.a.	803*	1,375	62

* 1959-61 only.

Sources: Meterage explicitly for gas is taken from Keller, 1958, p. 13, and Brenner, 1962, p. 83, except for 1959-65 which is from *GNIG*, 1963:10, p. 5, and *GP*, 1966:4, p. 2.

Data on total expenditures in exploration including exploratory drilling are taken from Keller, 1958, p. 12, for the first two periods, and extended to 1956-60 using data from Brenner, 1962, p. 89. *Exploratory expenditures* for gas are taken from Smysliakova, 1961, p. 63, from Brenner, 1962, p. 314, except for 1946-50, which is gotten by pricing out the exploratory footage at an estimated cost.

The figures for number of new deposits discovered are the sum of new fields and new deposits discovered on known oil fields. There are explicit Soviet statements for the first two periods, and for 1959-64, but for 1956-60 and 1961-64, it has been necessary to piece together scattered statements.

Gross discoveries were estimated as follows: M. F. Mirchink provides the following information on the status of the oil reservoirs of the U.S.S.R. (*Oppe razrabotka*, 1957, pp. 31-3).

Size classes (in terms of original recoverable contents)	Number of deposits	Share in total original contents (per cent)	
		1955 output as per cent of original recoverable contents	1955 output as per cent of original recoverable contents
Up to 1 million tons	230	3.9	5.2
1-10 million tons	150	22.4	3.7
More than 10 million tons	28	73.7	2.1
Total	408	100.0	—

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The next step is to adjust this to a comprehensive figure for the U.S.S.R. Azet-Golman accounted for 10.8 per cent of all A + B reserves on January 1, 1976 (I. Iker, 1978, p. 6), which makes the total for the U.S.S.R. 1,994 million tons. For the purposes of further calculations, this is rounded up slightly to 2.0 billion tons.

total heat of 1951-1946 (= 775-391) = 383 mtc $\times 3.3 = \underline{1254 \text{ Btu in A+B in 1/2 K}}$

assuming NRC value (3.0 Blk V₀) $1.7 \times 3.0 = 5.1$ STD 1/1/71 ← ③

	A + B reserves	Net increment	Production	Gross discoveries
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These results are quite consistent with a number of other Soviet statements on reserves. According to Brenner, 1962, p. 77, average annual increments

nt) paid a 20% deposit of 2.95 BTcashless which could have been

Billion (Barth P.) claimed that exposed residues of oil in the 1950s increased to 50% in 1969.
Netherlands Ministry of Nat. Jan 1969 p 2

(from 1980 to 30900) but Reserves in Alt C
categories increased by 517 and 4180

ВЫПУСК № 12571, Р.2, стр. VIII. 1951. Редакция: 1951. 1-е издание.
The first 10-sec. (1951-1952) experimental work in our country increased to 7 T.

Preserved in 1971-1973, in order to reach 1970 goals of 130-

IMPACT OF
OIL EXPORTS
FROM THE
SOVIET BLOC

Volume II

A Report of the
NATIONAL PETROLEUM COUNCIL

—1962—

The cost of production of crude oil (and associated natural gas) varies widely in the USSR with respect to location of deposits. By far the cheapest crude oil available in the USSR is that obtained from the highly prolific oil fields of the Urals-Volga. Conversely, apparently the most expensive crude is that produced on Sakhalin Island, as shown in the following tabulation: 32/

AREA OF PRODUCTION	1958 UNIT COST OF PRODUCTION AS PERCENT OF THE NATIONAL AVERAGE
Bashkir ASSR (Urals-Volga)	53.7
Tatar ASSR (Urals-Volga)	39.6
Kuybyshev Oblast (Urals-Volga)	42.1
Ukraine SSR	153.0
Turkmen SSR	165.0
Azerbaijan SSR	217.0
Chechen-Ingush ASSR	242.0
Sakhalin Island	331.0

Most of the decline in the national average cost of production has been possible through reductions in production costs in the Urals-Volga, which have been amplified because of the relatively high share these fields provide in the total annual output. The decline in the cost of production at the fields of the Ukraine have not been particularly significant as the volume of production is only of minor proportion. Similarly the effect of the 47 percent increase in production costs from the Chechen-Ingush fields largely has been cancelled by the declining role which can be attributed to the output from these fields. Fluctuations in the cost of production of crude oil (and associated natural gas) in the USSR by selected area of production for the years 1950-58 are given in Table 3-26.

4. Reserves

Not since the late 1930's has the Soviet Union published any definitive information on the amount of proved reserves of crude oil. Some basis for estimating Soviet proved reserves was given to the U.S. oil delegation which toured the USSR in August, 1960; and as a result of examination of the information acquired, at that time it was considered that the current proved reserves/crude oil production ratio in the Soviet Union was on the order of 22 to 1. 25/ Since then, further analysis

proved reserves of crude oil, plus additional references, has indicated that this ratio probably should be revised downward, to 20 to 1 for the period 1950-61. During the Seven Year Plan, the proved reserves of crude oil are to increase by 1.7 times. ^{36/} If this level is achieved, then the reserves/production ratio in 1965 (production in 1965 taken at the planned level) would be on the order of 16 to 1.

The estimates of proved reserves of crude oil in the Soviet Union, as agreed on by the Committee, reflect these two ratios and are as follows:

<u>END OF YEAR</u>	<u>BILLION METRIC TONS</u>
1950	0.758
1955	1.416
1958	2.264
1960	2.958
1961	3.320
1965 Plan	3.848

5. Projections for the Future

In the last few years the Soviet press has reported new discoveries of crude oil in Siberia and on the Mangyshlak Peninsula located on the Eastern shore of the Caspian. The oil discovery made on the Mangyshlak Peninsula is considered by the USSR to be one of the important discoveries of the 1960's. This discovery, described as a multi-billion barrel field, reportedly has some 40 pays, which are extremely porous and permeable. In addition, other discoveries have been reported at Prorva, Barankul, and Kenkiyak, to the north of the Mangyshlak Peninsula along the shore of the Caspian Sea. These finds could support the development of Western Kazakhstan as a leading oil producing area.

In October, 1961, the USSR announced plans for the development of production of crude oil for the twenty-year period 1961-80. By the close of this period, crude oil output is to reach to 690-710 million tons, ^{37/} with output in the intervening years to reach 390 million tons in 1970 ^{38/} and 545 million tons in 1975. ^{39/} Although the Soviet oil industry has in recent years demonstrated its ability to achieve the planned levels of production, the very magnitude of the output of crude oil foreseen for 1980 is sufficient to warrant a close examination of the effort required if such a goal is to be attained.

First, it is apparent that a very substantial volume of crude oil must be found. Based on statements by Soviet authorities with reference to the current rate of depletion of oil fields in the USSR, it may be estimated that the remaining in-ground reserves in the terminal year of 1980 will be about 15 times the production or about 10.5 billion tons (using 1960 production as the mid-point of the range of 690-710 million tons). January 1, 1961, reserves have been estimated at 20 times 1960 production, or 2.96 billion tons (21.6 billion barrels). New finds, therefore, must amount to the increase in in-ground reserves of about 7.5 billion tons, plus interim production on the order of 8.3 billion tons, or about 15.8 billion tons (115.3 billion barrels). From the geological information available, the Committee concludes that there should be at least this much oil in place in the USSR. For comparison, total U.S. crude oil reserves found and developed as of January 1, 1962, were on the order of 100 billion barrels, of which 67.8 billion barrels represented cumulative production.

The 15.8 billion tons of crude oil programmed to be found during the 20-year period 1961-80 represents an impressive task when compared with oil finds since World War II. From 1919 through 1960, the USSR produced about 1 billion tons of crude oil and increased the terminal reserves by 2.57 billion tons. Thus new reserves of 3.57 billion tons were found in this period.

Discussion of the drilling program envisaged for 1961-80 has been presented elsewhere in the report. It has been stated that the total exploration drilling for crude oil and natural gas during 1961-80 will be 150-160 million meters and that gas exploration drilling alone will reach 86.5 million meters. Thus by difference an average value for crude oil exploration may be estimated as 78 million meters. Plans for crude oil development drilling have not been announced publicly, although it has been stated that a total of 150 thousand "development and related" wells would be completed. If an average well depth of 2,100 meters is assumed, then development drilling requirements would be 315 million meters.

With these assumptions, it is possible to compare the Soviet expectations of discovery/drilling ratios with past experience:

VS. 1960
1961-1965 36
1966-1970 41
1971-1975 51
1976-1980 51
2 20

ITEM	1946-60	1961-80
Exploration Drilling (million meters)	29.40	78.00
Development Drilling (million meters)	35.40 (Est.)	315.00
TOTAL DRILLING	64.80	393.00
Cumulative Crude Oil Production (billion metric tons)	1.00	8.30
Increase in in-ground proved reserves (billion metric tons)	2.57	7.50
TOTAL NEW FINDS (billion metric tons)	3.57	15.80
Crude Oil Discovered Per Meter of Exploratory Drilling (tons per meter)	121.00	203.00
Crude Oil Discovered Per Meter of Total Drilling (tons per meter)	55.00	40.00

In the above tabulation, the apportionment between exploratory and development drilling for 1961-80 is suspect, as it indicates a substantially different ratio than the 1946-60 period. It is unlikely that the USSR should expect to find in the future 203 tons of crude oil per meter of exploratory drilling, when past data show a discovery ratio of 121 tons per meter--particularly in view of continuing reports that future fields are likely to be found at increasingly greater depths. However, the rate of 40 tons of crude oil found per meter of total drilling appears reasonable and conservative when compared with the 1946-60 experience of 55 tons per meter. It is possible that the 150 thousand wells defined as "development and related", from which the development drilling estimate is derived, include some wells of a type that in earlier statistics were considered as exploratory wells. Nevertheless, the estimate of 393 million meters of total drilling for crude oil appears consistent with an independent Soviet statement that total oil and gas drilling during the 20-year period would reach 500 million meters.

It is probable that the USSR has made realistic estimates of the drilling effort required to achieve the future production goals. Results during 1958-61 showed that production targets were exceeded although drilling plans were not met. This situation will not necessarily continue in the long-term future and the USSR apparently recognizes this fact. The

achievements of the oil program today are closely related to the finding of a number of major deposits during the 1950's. The oil industry may not be so fortunate in the future.

As shown in Table 3-27, which represents the Soviet estimates of the probable regional distribution of production of crude oil in the USSR in 1980, the Urals-Volga is to continue to be the major source of production, although the share anticipated for 1980--slightly more than 50 percent--will represent a decline from the current position. Although the likelihood of finding new oil fields of major importance in the Urals-Volga has been lessened, prospects of finding a large number of medium-size and small-size fields are excellent. A large portion of the increase in production is expected to come from an extension of existing oil producing areas, primarily through deeper drilling in such areas as Baku and Grozny, and from improvements in petroleum technology.

TABLE 3-27

SOVIET ESTIMATES OF PROBABLE REGIONAL DISTRIBUTION
OF PRODUCTION OF CRUDE OIL IN THE USSR - 1980

<u>REGION</u>	<u>MILLION METRIC TONS</u>	<u>PERCENT OF TOTAL</u>
Urals-Volga	350	50.0 <u>a/</u>
West Siberia)		
East Siberia)	42	6.0 <u>a/</u>
Far East)		
Ukraine --	42	6.0 <u>a/</u>
Kazakhstan	35	5.0 <u>a/</u>
Turkmen	28	3-4.0 <u>a/</u>
North Caucasus)		
Uzbek)	154	22.0 <u>b/</u>
Kirgiz)		
Tadzhik)		
Azerbaijan	<u>49</u>	<u>7.0</u> <u>a/</u>
TOTAL	700 <u>c/</u>	100.0

a/ 40/ N. A. Khorov, *1982* 11-6

b/ By difference.

c/ Mid point of 690-710 million ton range.

In summation, it is not feasible to forecast success or failure of achieving the long range production goals. The

PRODUCTION PROBLEMS

Soviet production plans are ambitious for the coming decade and heavily dependent on successful development of West Siberian oil and gas reserves. Many problems have arisen that may have been overlooked in setting future goals, including:

- 1) The adequacy, or quality of proved reserves.
- 2) The location of new reserves and pipeline distances to markets.
- 3) The limitations of available technology and equipment.

In 1980, the Soviets plan to produce 230-260 million tons of oil and 230-260 billion cubic meters of gas per year from West Siberian fields. ^{300 (1 Jan 74)}

In January 1971, two eminent Soviet geologists indicated that West Siberian oil reserves were inadequate to support production rates of more than 130 to 150 million tons annually, which is about the level expected in 1976. Furthermore, output from the 3 largest producing republics in the Urals-Volga region is expected to stabilize at 175 million tons per year during 1971-1975 period and then gradually decrease.

In April 1972, Soviet Oil Minister V.D. Shashin disclosed that during 1971-1975, 300 million tons of new producing capacity would have to be developed, including 147 million tons for net growth and 153 million tons to offset depleted capacity. This is an exceptionally large requirement in terms of prior Five Year Plans. These capacity requirements have been revised twice since then.

Producing Capacity Requirements in Millions of Tons of Oil per year

<u>5 Year Plan</u>	<u>Net Capacity</u>	<u>Depleted Capacity</u>	<u>Total</u>
1961-1965	93.8	68.3	162.1
1966-1970	110	91.1 (Plan)	195 (Plan)
1971-1975 (Plan)	147	153	300-310-320-384 ⁺
1976-1980 (est)	50-100	200-300	250-400

During recent years, the Soviets drilled approximately 4,000 wells and some 11 million meters which has enabled crude oil production to increase by about 22,000,000 tons annually. The current relationship between new producing capacity and total drilling is about 2 tons per year per meter, while the new capacity per well ratio is approximately 5500 tons per year. The announced requirement of 147 million tons of net capacity during 1971-1975 would therefore imply a need to drill almost 27,000 wells and more than 70 million meters. As depletion of old capacity increases, the drilling problem will become more acute.

About 70% of the oil fields in the USSR are under water-flood and normal rates of injection are about 2 tons of water per ton of oil extracted. Water injection occurs under pressures which frequently exceed formation pressures by a considerably wide margin.

In February 1972, there were 1,360 producing oil wells in West Siberia located in 10 fields which produce at an average rate of 108 tons per day.

About 1200 producing oil wells were drilled in West Siberia during the 1966-1970 period, or about 240 wells per year. An unknown number of injection wells were also completed. In 1971-1975 the Soviets plan to drill 7-7.5 million meters in West Siberia with 87 rigs, which is said to be 10% of the rigs in the USSR. Most producing zones are 1800 to 2500 meters deep.

The largest West Siberian oil field is Samotlor which is expected to produce 50 to 70 million tons per year in 1975 and 100 million tons by 1980 from 3000 - 7000 wells. This field is said to contain over 2 billion tons of oil. Well yields range from 33 to 900 tons per day but probably average less than 250 tons.

West Siberian sandstone reservoirs contain considerable amounts of clay in-filling which reduces permeability and water encroachment is a serious problem. Otherwise reservoir parameters resemble those of the Urals-Volga fields and "coning" may ruin many fields. Reservoir pressures 200-250 KG/CM² at 2200 meter depths, Porosity 16-32%, Permeability 200-1200 md. (Soviets now admit Tyumen reservoirs are inferior to Urals Volga Devonian fields)

1975 Production Goals are500 Million Tons of Oil and 320 Billion m³ of Gas

The drilling "bottleneck" becomes more critical for meeting 1975 and 1980 production goals and maintaining a 10:1 Reserve-Production ratio based on 1961-1968 discovery rates, recent plans and performance.

<u>1969-1975 Period</u>	<u>Oil</u>	<u>Gas</u>
Estimated Cumulative Production	2.834 billion tons	1.670 trillion m ³
Additions to A&B Reserves for 10:1 R/P 1/1/1976 (i.e. 500 MTO x 10 years and 320 BCM x 10 years)	5.000 billion tons	3.200 trillion m ³
	7.834 billion tons	4.870 trillion m ³
Minus Unproduced A&B reserves 1/1/1969	-4.500 billion tons	-2.500 trillion m ³
Planned discoveries 1969-1975	3.334 billion tons	2.370 trillion m ³
Divided by historic discovery rates	55 tons/m	110,000 m ³ /m
Estimated Total Drilling Requirement	60,618,181 meters	+ 21,545,455 meters
		= 82,163,636 meters
Less 1969 + 1970 meterage		-22,951,000
1971-1975 undrilled meterage		= <u>59,212,636 meters</u> over 5 years

When the US R/P reached and fell below 10:1, domestic oil production stabilized and commenced to decline - prior to 1973 price changes. If this R/P is not maintained USSR oil output could "plateau" during 1976-1980 with Ural-Volga fields depleting at 1-1.5% per year.

Assumed 1980 Goals of 550 million tons of Oil and 420 billion
m³ of Gas

1969-1980 Period	Oil	Gas
Estimated Cumulative Production	5.484 billion tons	3.570 trillion m ³
Additions to A&B Reserves for 10:1 R/P on 1/1/1981 (i.e. 550 MTO x 10 years and 420 BCM x 10 years)	5.500 billion tons	4.200 trillion m ³
	10.984	7.770
Minus Unproduced A&B reserves 1/1/1969	-4.500 est.	-2.500 est.
Assumed Discoveries 1969-1980	6.484 billion tons	5.270 trillion m ³
Divided by historic discovery rates	55 tons/m	110,000 m ³ /m
Estimated Total Drilling Requirement	117,890,909 meters	+ 47,909,091 meters
		= 165.8 million meters
	Less 1969 + 1970 meterage	- 22.9 million meters
		<u>142.8 million meters</u> over 10 years

Estimated & Actual Production of Oil and Gas After 1960-1962

NPC Study

<u>Cumulative Production</u>	<u>Oil</u>	<u>Gas</u>
actual 1961-1965	1.024 billion tons	459 billion m ³
actual 1966-1970	1.548 billion tons	849 billion m ³
Plan 1971-1975	2.153 billion tons	1.291 trillion m ³
1969 actual	238.3 million tons	181.121 billion m ³
1970 actual	352.6 million tons	197.94 billion m ³
1971-75 Plan (500 MTO Max)	2,153 million tons (320 BCM Max)	1,291 billion m ³
1969-1975 production	2.834 billion tons	& 1.670 trillion m ³
1969-1980 production	5.484 billion tons oil	& 3,570 trillion m ³ gas

1960-1962 NPC Report Methodology for EstimatingOil and Gas Discovery Rates

<u>Jan 1961-Dec 1968 Period</u>	<u>Oil</u>	<u>Gas</u>
Cumulative production	1.867 billion tons	.928 trillion m ³
Additions to A&B Reserves	1.500 billion tons	.646 trillion m ³
Total Discoveries	3.387 BTO	1.574 TCMG
a) Divided by Total Exploratory Drilling	26.66 million meters	
	= 127.04 tons/meter ^{1/}	= 59,040 m ³ /meter
) Divided by Total Meters Drilled	63.7 million meters	(for gas only 15.0 million meters)
	= 53.17 tons/meter ^{1/} (55)	= 104,933 m ³ /m ² / (110,000)

1/ NPC (1962 Vol II p. 108) estimated 121 tons/m of exploratory drilling and 55 tons/m of total drilling for A&B reserves in the 1946-1960 period. Recently the Soviets claimed 169 tons/m in 1961-1965 and 220 tons/m in 1966-1970 for exploratory drilling and A&B&C reserves. (Nefte Gazovaya Geofizika No. 1, Jan. 1971, p. 3-7)

2/ Gazovaya Promyshlennost (No. 1, 1971, p. 1,2) cited a discovery rate of 202,000 m³/m of A&B reserves at a unit cost of 1.06 Rubles for 1951-1965. The rate was about 300,000 m³/m in 1959 and it declined to 110,000 m³/m in 1965. During 1959-1965, data provided by A.K. Kortunov and M.S. L'vov indicate discovery rates of 147,702 m³/m and 150,500 m³/m respectively for A&B reserves. More recently, Gazovaya Promyshlennost (No. 5, 1971, p. 7) cites a discovery rate of 1,310,000 m³/m for A&B&C reserves for the entire USSR and 14,500,000 m³/m for West Siberia during 1966-1970.

Petroleum Deposits of the West Siberian Lowland

1. Area: This sedimentary basin contains some 3.2 million square kilometers which has been classified as follows:
 - a) 1 million km² is unprospective,
 - b) .5 million km² is slightly prospective,
 - c) 1.65 million km² is prospective, and
 - d) at least 168 petroleum deposits have been discovered to date.
2. Sedimentary Rocks: According to qualified western observers as many as 300 anticlinal structures have been mapped in Tyumen. Most of the discoveries of oil and gas have occurred between 600 and 3200 meter depths in rocks of Mesozoic and Cenozoic age.
 - a) Most of the oil deposits are located above 2400 meter depths in the shallow middle Ob portion of the basin. Reservoirs have been found in middle and upper Jurassic as well as lower Cretaceous rocks -- Valangin, Goteriv and Barrem -- which are basically marine and coastal type sandstones.
 - b) Most of the natural gas deposits are located above 3200 m depths farther north in the Ob Gulf region among Cenomanian rocks which are continental type sandstones.
 - c) Most deposits have several overlying producing zones, however, reservoir characteristics change rapidly in the lateral plan due to intermittent clay and silt infilling.*
Porosity may vary from 6% to 32%.
Permeability may vary from 50 md to 4000 md.
3. Reserves: At least 5 billion tons or 35 billion barrels of oil and 10 trillion cubic meters or 350 trillion cubic feet of gas have been discovered (in the proved and probable reserve categories) by drilling.
 - a) The largest deposits can be ranked approximately as follows:

* Soviet geologists have intimated that the Tyumen oil deposits may be inferior to the Urals-Volga reservoirs, where many of the best fields are associated with Devonian reefs, in addition to the sandstone, shale, silt sequence which is common to both oil bearing regions.

<u>Oil</u>	<u>Billion BO</u>	<u>Natural Gas</u>	<u>Trillion Cu Ft</u>
Samotlor	> 15	Urengoy	140-210
Federovo	> 5	Medvezhye	55
Sosninsk	> 4	Zapolyarnyy	55
(Sosnimo-Sovetskoye-Medvedyev)		Yamburg	35
		Yubilenoye	28
Ust Balyk	> 3	Komsomolskoye (N & S)	15
Mamontovo	3		
Zapadno-Surgut	2	Gubkin	12
Pravdinsk	1.5	Taz	4
Urengoy (condensate)	1.0	Messoyaka	2
		Pelyatkinskoye	2
Salym	.7	Vengapur	2
Region	<u>.7</u>		<u>2</u>
	35.9		350+

4. Quality of the Oil and Gas Reserves

- a) All of the natural gas is of high quality being 92%-98% methane for the most part and it appears to be void of any inert and corrosive elements.
- b) The crude oil of the eastern most fields near Samotlor contains 1.3% sulfur or less, but much of the oil including Samotlor crude is only .85% sulfur by weight. Near Ust-Balyk and Surgut, the sulfur content is higher and it ranges between 1.3% to 2.2%. Specific gravity of most Tyumen oil averages about .85.
- c) Practically all of the oil and gas reservoirs are characterized by low to normal pressures

and a water drive. The water drive mechanism can be active in some instances; however, in many cases it has been found to be very weak or stagnant, due to permeability changes, horizontal stratification, or only slight tilting of the reservoir beds. Generally, the production of either oil or gas will usually be accompanied by water and perhaps a rapid depletion of bottom hole pressures, unless proper countermeasures are taken immediately.

d) Average well yields may range from 350 to 700 barrels daily for most oilfields but the Samotlor wells are said to be better and they may average about 1800 barrels per day. Natural gas wells may produce 35 to 105 million cubic feet of gas per day, but Urengoy wells have been reported to produce over 200 million. However, such natural flow rates can not be long sustained because of low to average reservoir pressures which would be a limiting factor. ★

e) Surface conditions at most Tyumen fields must be described as terrible with tundra and 600 to 1200 feet of permafrost covering all of the natural gas deposits; while taiga, peat bogs, or swamps cover most of the oil accumulations.

Gosplan's Nefte Gaz, No. 3, 1973 (872-22) points out that production will reach 65 mtpd by 1974. The Surgut Region wells average 500 tons per day and the Zhigansk wells average 100 tons. Production will total 160 mtpd in 1980 from this region.

★ Western experts visiting Samotlor and Tyumazy indicate water problems are intensifying at Samotlor and that Tyumazy fluid production is 20% water. If wells produce > 400 BFP they are converted to Red type pumps. Over 500 wells in Tyumazy were on pump in 1973 and they plan to convert 400 more in 1974.

★ Most east flow new Russian fields will be lost to the west by 1975 and the west flow fields will be lost by 1980.